Trajectory optimization for underwater gliders

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The problem of finding of the shortest trajectory of underwater glider, which joins two oriented points with given constraints on curvature is presented. The underwater glider is driven only via system of actuators, which consists of an element, which is controlling the buoyancy of glider (called buoyancy engine) and moving batteries, which are controlling location of glider's center of gravity to maneuver. The absence of any other thrusts, screws or engines leads to strong influence of hydrodynamic forces on its movement and, as a result, to the complicated nonlinear mathematical model.

First time, a similar class of problems was investigated by A. A. Markov (1889) in case of railway projection [1]. Later, L. E. Dubins' results on this problem [2], presented in 1957, were widely applied to a cars' motion. Nowadays, the revival of interest in such problems is associated with tremendous number of applications in robotics, for example in the theory of motion of autonomous underwater vehicles.

The report presents an overview of the main works which generalize the solutions of Markov-Dubins problem which were obtained until now. In modern works, since J.-D. Boissonnat's report in 1991 [3], the Pontryagin's Maximum Principle is using as a foundation to solve the problem.

In this paper we consider new problem statements that take into account the specific dynamics of a rigid body in dense incompressible fluid.

[1] Markov A. A. Some examples of the solution of a special kind of problem on greatest and least quantities.(Russian), Soobsheniya Kharkovskogo Mat. Obshestva, 1889, 1:250-276.

[2] Dubins L. E. On curves of minimal length with a constraint on average curvature and with prescribed initial and terminal positions and tangents. American Journal of Mathematics, 1957, 79:497-516.

[3] Boissonnat J.-D., Cerezo A., Leblond J. Shortest path of bounded curvature in the plane. Research Report RR-1503, INRIA, 1991, 1-20.